Fly Ash Slurry Filtration Using Curlex® Sediment Log®

Quantifying Total Suspended Solids and Turbidity Reduction

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By:
Kurt Kelsey, M.S., CPESC, CPSWQ
Director of Technical Services
&
Missy Murley
ErosionLab Manager

American Excelsior Company®
ErosionLab®
831 Pioneer Avenue
Rice Lake, WI 54868
USA
www.Curlex.com

STUDY SITE
All activities conducted for this evaluation were completed at ErosionLab® (www.erosionlab.com), which is a large-scale erosion and sediment control research laboratory located near Rice Lake, WI, USA. ErosionLab is owned and operated by American Excelsior Company®.

OBJECTIVE
Quantify reduction of total suspended solids (TSS) and turbidity of fly ash slurry when using Curlex® Enforcer® and Curlex® Sediment Log®.

BACKGROUND
Fly ash samples were collected from First Energy in Ohio. Fly ash is residue from coal-fired plants. Fly ash can become entrained in runoff during rainfall events so it is imperative to determine earth-friendly solutions that can remove fly ash from contaminated runoff before being discharged.

METHODS
Channel simulators were built to determine the reduction of TSS and turbidity of fly ash slurry exposed to Curlex Enforcer and Curlex Sediment Logs. A 75:1 water to fly ash slurry consisting of 45 gal of water to ≈80 oz of fly ash (170,344 ml water to 2,271 g of fly ash) was filtered when it flowed over Curlex Enforcer and through a Curlex Sediment Log fiber matrix. TSS and turbidity of the fly ash slurry were quantified before filtering began and every three minutes after passing through the channel simulator. Figure 1 shows the fly ash slurry being mixed.

Figure 1. Fly ash and water slurry being mixed.

Channel Simulator:

The channel simulators were built to the dimensions shown in Figures 2 – 4.

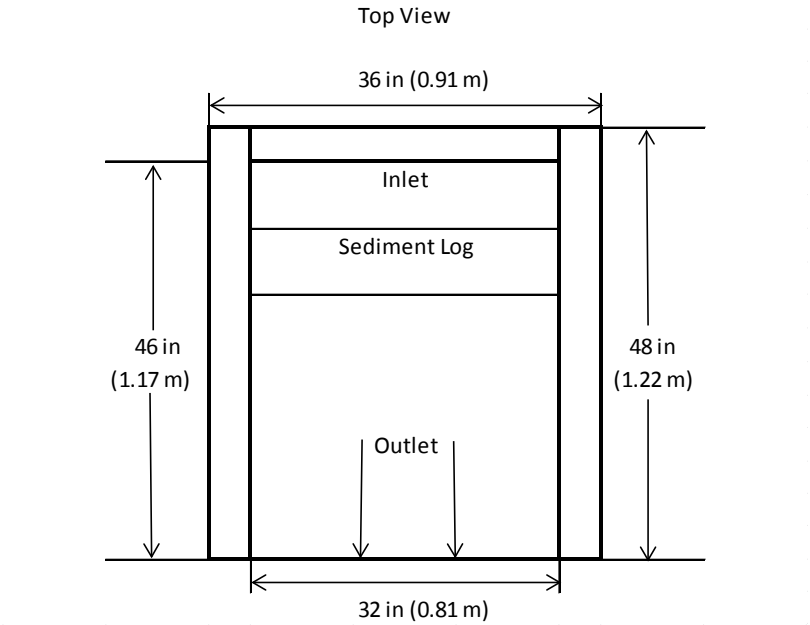

Figure 2. Top view of channel simulators.

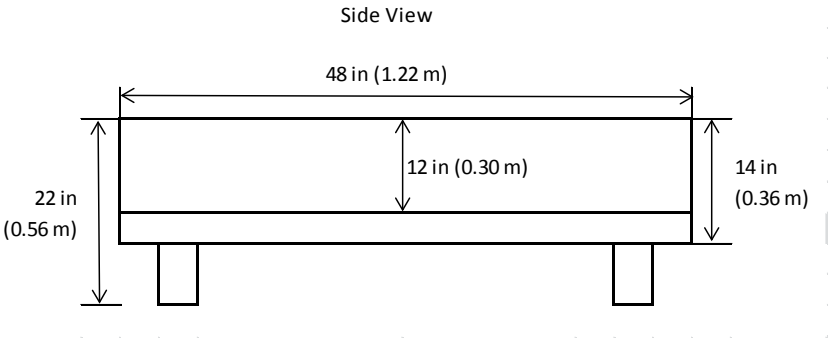

Figure 3. Side view of channel simulators.

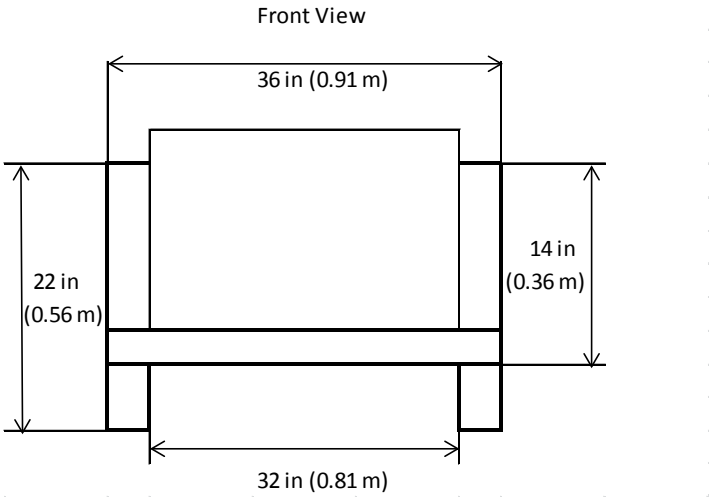

Figure 4. Front view of channel simulators.

BMP Evaluated

Curlex Enforcer and Curlex Sediment Logs, as manufactured by American Excelsior Company, were used during the evaluation. Curlex Enforcer contains naturally seed free, renewable Great Lakes Aspen excelsior fibers that are colored green for aesthetics and bound by two layers of extra heavy-duty black UV stabilized netting. Curlex Sediment Logs contain uncolored Great Lakes Aspen excelsior fibers encased in tubular containment material.

Installation

Curlex Enforcer was installed on the bottom of the channel simulator and anchored with staples. A Curlex Sediment Log was installed on top of the Enforcer. The scaled-down Curlex Sediment Logs were approximately 2.7 ft (.81 m) in length, but the material contained the same density as full scale Curlex Sediment Logs to maintain the same flow through characteristics. Table 1 provides the properties of the scaled down Curlex Sediment Logs used in the channel simulator as compared to standard sized Curlex Sediment Logs.

Table 1. Properties of standard Curlex Sediment Logs and scaled down Curlex Sediment Logs that were used in the channel simulator.

Curlex Sediment Log Type	Nominal Diameter (in [cm])	Length (ft [m])	Density (lb/ft^3 [kg/m^3])
Standard	12 [30.5]	10 [3.1]	2.5 [40.0]
Scaled Down Test Log	12 [30.5]	2.7 [.81]	2.5 [40.0]

A 2 in (5.1 cm) x 8 in (20.3 cm) board was clamped to the top of the channel simulator to lightly anchor the Curlex Sediment Log to the bottom of the channel simulator (Figure 5). Spray foam was used to fill any gaps between the Curlex Sediment Log and the side of the channel simulator (Figure 5). The seam along the Curlex Sediment Log and side of channel simulator was caulked to prevent flow around the Curlex Sediment Log and the side wall. A 3 in (7.6 cm) x 32 in (81.3 cm) wood fixture was placed as a gasket at the interface between the Curlex Sediment Log and the channel bottom on the inlet side of the channel simulator (Figure 6).

Figure 5. Curlex Sediment Log installed in channel simulator.

Figure 6. Inlet reservoir of channel simulator.

Recirculated Channelized Flow Simulation

For each of the three simulations, a 75:1 water to fly ash slurry consisting of 45 gal of water to ≈80 oz of fly ash (170,344 ml water to 2,271 g of fly ash) was created. A 1/6 horse power pump was used to agitate the fly ash slurry. The fly ash slurry was then pumped behind the Curlex Sediment Log into the inlet reservoir (Figure 7). A return channel (Figure 8) on the downstream end of the channel simulator collected the water after it filtered through the Curlex Sediment Log then flowed across the Curlex Enforcer (Figure 9 and 10).

Figure 7. Fly ash slurry in the inlet reservoir.

Figure 8. Return channel to supply tank of channel simulator.

Figure 9. Close up of filtered fly ash slurry exiting a Curlex Sediment Log early in a test.

Figure 10. Flow through Curlex Sediment Log and across Curlex Enforcer.

Two 1/6 horse power pumps were used to recirculate the water through the channel simulator. The fly ash slurry was pumped from the supply tank into the inlet reservoir, through the Curlex Sediment Log, across the Curlex Enforcer, into the return channel, and back into the supply tank where the process started over. Each test ran for 90 minutes. Initial samples were collected from the mixing tank prior to the start of water being pumped through the channel simulator. Samples were then collected after the first pass through and every three minutes throughout the 90-minute test.

Laboratory Analyses

Grab samples obtained during testing were analyzed for TSS. Each 8.5 fl oz (250 ml) sample bottle was weighed prior to testing, after samples were collected, and after being removed from a forced air laboratory oven. Bottles were removed from the oven, which was set at 120 °F (49 °C), after all moisture had evaporated from the bottles. All samples were weighed using an Adam Equipment Model PGW 3502e Scale [max 3,500 g; d=0.01 g] (Figure 11). The PGW 3502e Scale was also utilized to measure fly ash mass that was added to water to create the slurry used in each test.

Figure 11. Adam Equipment Model PGW 3502e scale used for fly ash mass and TSS analyses.

Additional grab samples obtained during testing were analyzed for turbidity. All 1.5 oz (45 ml) NTU samples were measured using a LaMotte 2020we Turbidity Meter (Figure 12).

Figure 12. LaMotte 2020we Turbidity Meter used for NTU measurements.

RESULTS

Starting conditions of the fly ash slurry TSS for the three tests were 11,283.21 ppm, 5,194.91 ppm, and 5,429.90 ppm. Table 2 contains TTS measurements over time of fly ash slurry being filtered by Curlex Sediment Logs and Curlex Enforcer in tabular format.

Table 2. TSS measurements over time of fly ash slurry being filtered by Curlex Sediment Logs and Curlex Enforcer.

Time into Test	Test #1 (ppm)	Test #2 (ppm)	Test #3 (ppm)
Sample #1 - Tank	11,283.21	5,194.91	5,429.90
Sample #2 - First Pass	7,934.66	5,230.56	6,225.65
Sample #3 - 3 min	6,571.83	5,893.99	6,691.30
Sample #4 - 6 min	4,997.34	5,385.34	5,916.19
Sample #5 - 9 min	3,867.17	5,161.93	5,758.08
Sample #6 - 12 min	3,345.71	4,918.17	3,707.93
Sample #7 - 15 min	2,770.31	4,486.54	4,559.45
Sample #8 - 18 min	2,315.59	4,140.87	4,141.21
Sample #9 - 21 min	2,253.82	2,940.34	2,994.87
Sample #10 - 24 min	1,976.04	2,577.00	2,763.46
Sample #11 - 27 min	1,926.86	2,569.65	2,648.31
Sample #12 - 30 min	1,594.77	2,458.71	2,394.52
Sample #13 - 33 min	1,681.71	2,376.76	2,093.71
Sample #14 - 36 min	1,471.91	2,126.96	1,957.03
Sample #15 - 39 min	1,357.97	2,089.82	2,088.88
Sample #16 - 42 min	1,390.37	2,133.60	1,969.96
Sample #17 - 45 min	1,398.08	3,579.42	3,728.90
Sample #18 - 48 min	1,187.16	3,309.25	3,421.73
Sample #19 - 51 min	1,189.79	3,144.65	3,192.67
Sample #20 - 53 min	986.27	2,901.94	2,923.98
Sample #21 - 56 min	1,020.70	1,925.83	1,991.95
Sample #22 - 59 min	1,034.77	1,942.30	1,684.33
Sample #23 - 62 min	1,065.44	1,919.46	1,961.99
Sample #24 - 65 min	940.39	1,941.75	1,599.15
Sample #25 - 68 min	1,100.02	1,801.29	1,677.92
Sample #26 - 72 min	1,062.44	1,792.77	1,502.05
Sample #27 - 75 min	1,108.42	1,756.61	1,590.34
Sample #28 - 78 min	943.82	1,673.20	1,519.82
Sample #29 - 81 min	787.76	1,714.01	1,345.57
Sample #30 - 84 min	824.16	1716.25	1,342.77
Sample #31 - 87 min	861.54	1574.68	1,175.14
Sample #32 - 90 min	946.50	1692.54	1,378.64

Figure 13 graphically displays the TSS reduction over time of fly ash slurry filtered by Curlex Sediment Logs and Curlex Enforcer.

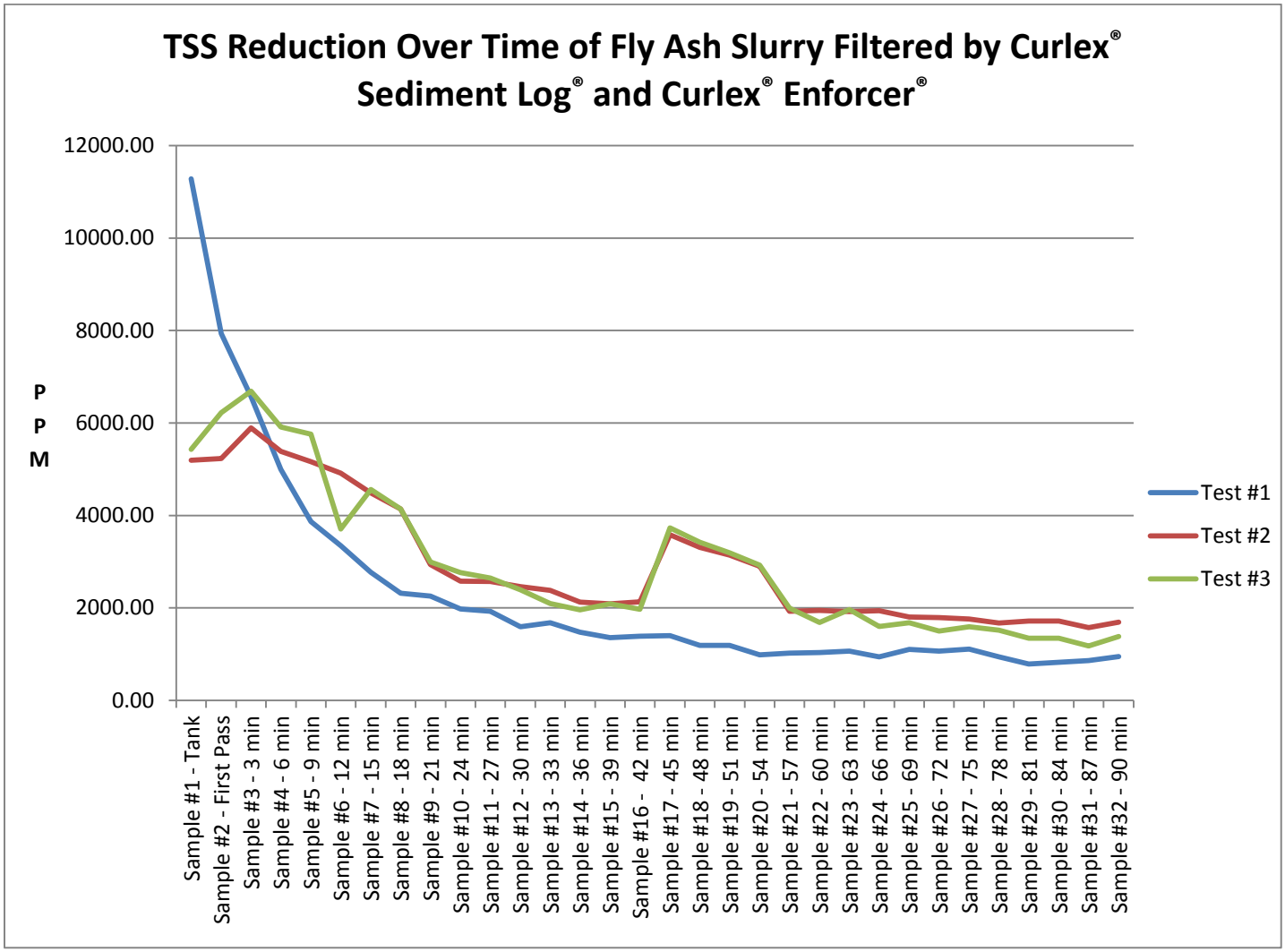

Figure 13 - TSS reduction over time of fly ash slurry filtered by Curlex Sediment Logs and Curlex Enforcer.

Starting conditions of the fly ash slurry NTU for the three tests were 5,556 NTU, 4,868 NTU, and 5,210 NTU. Table 3 contains NTU measurements over time of fly ash slurry being filtered by Curlex Sediment Logs and Curlex Enforcer in tabular format.

Table 3. NTU measurements over time of fly ash slurry being filtered by Curlex Sediment Logs and Curlex Enforcer.

Time into Test	Test #1 (NTU)	Test #2 (NTU)	Test #3 (NTU)
Sample #1 - Tank	5,556	4,868	5,210
Sample #2 - First Pass	5,004	4,523	4,966
Sample #3 - 3 min	4,196	4,310	4,932
Sample #4 - 6 min	3,884	4,220	4,994
Sample #5 - 9 min	3,723	4,116	4,744
Sample #6 - 12 min	2,782	3,620	4,558
Sample #7 - 15 min	2,538	3,444	4,254
Sample #8 - 18 min	2,223	3,557	4,053
Sample #9 - 21 min	1,942	2,999	2,768
Sample #10 - 24 min	1,797	3,001	2,415
Sample #11 - 27 min	1,763	2,882	2,370
Sample #12 - 30 min	1,642	2,775	2,153
Sample #13 - 33 min	1,583	2,756	2,107
Sample #14 - 36 min	1,545	2,364	2,079
Sample #15 - 39 min	1,422	2,295	1,964
Sample #16 - 42 min	1,357	2,290	2,065
Sample #17 - 45 min	1,226	3,702	3,980
Sample #18 - 48 min	1,175	3,436	3,895
Sample #19 - 51 min	1,192	3,338	3,591
Sample #20 - 53 min	1,166	3,309	2,910
Sample #21 - 56 min	1,097	2,255	1,884
Sample #22 - 59 min	1,067	2,130	1,772
Sample #23 - 62 min	1,010	2,056	1,658
Sample #24 - 65 min	1,086	1,668	1,601
Sample #25 - 68 min	971	2,011	1,477
Sample #26 - 72 min	995	2,130	1,448
Sample #27 - 75 min	926	1,972	1,505
Sample #28 - 78 min	921	1,769	1,369
Sample #29 - 81 min	918	1,869	1,344
Sample #30 - 84 min	907	1,806	1,207
Sample #31 - 87 min	911	1,601	1,272
Sample #32 - 90 min	917	1,585	1,169

Figure 14 graphically displays the NTU reduction over time of fly ash slurry filtered by Curlex Sediment Logs and Curlex Enforcer.

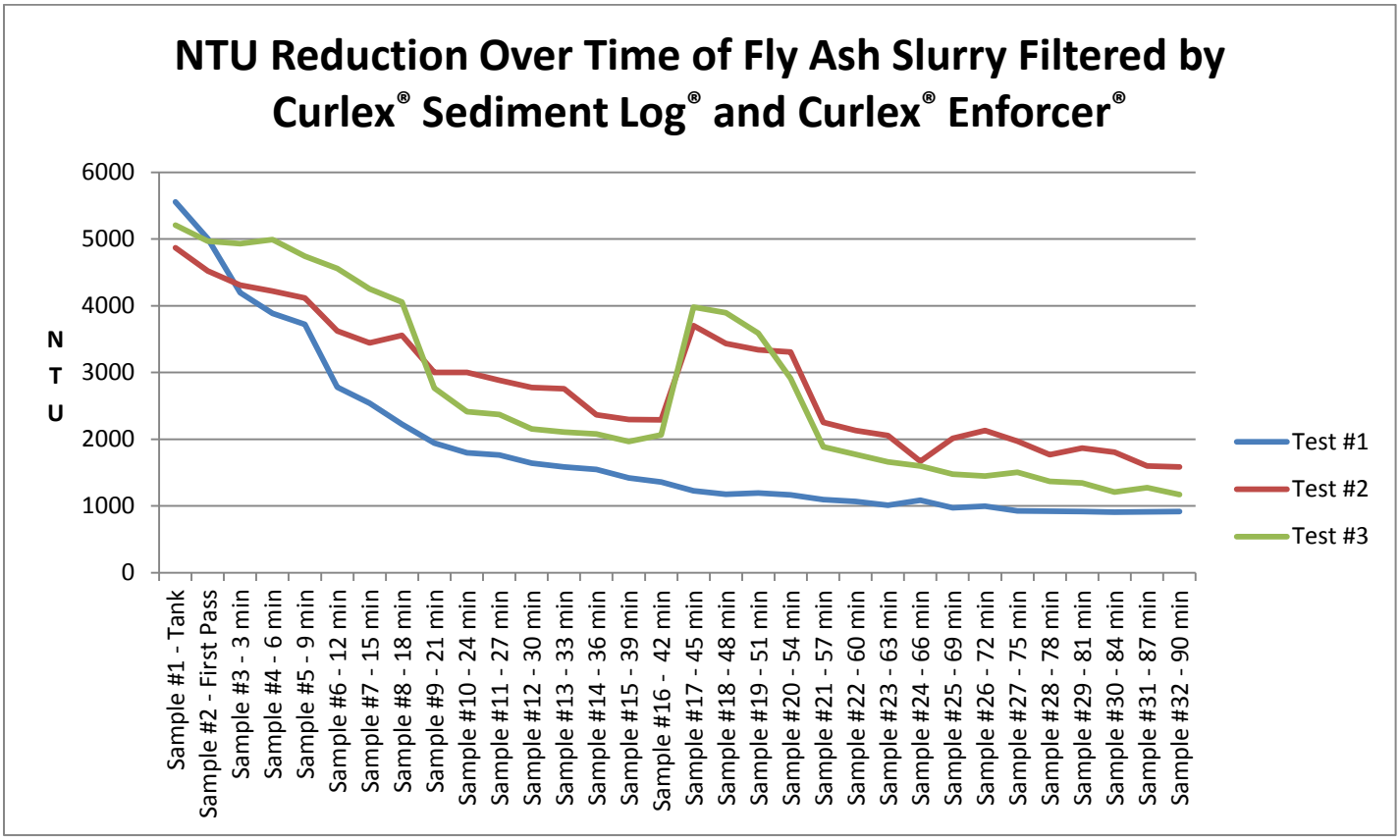

Figure 14. NTU reduction over time of fly ash slurry filtered by Curlex Sediment Logs and Curlex Enforcer.

OBSERVATIONS

- The Curlex Sediment Log and Curlex Enforcer removed fly ash from the slurry throughout the duration of the test. Fly ash was collected within the Curlex Sediment Log excelsior fiber matrix and within and under the Curlex Enforcer (Figures 15-17).

- TSS samples settled at least 48 hours before decanting. The fly ash adhered to the bottom of the bottle, which helped with decanting.

CONCLUSION

- Curlex Sediment Logs and Curlex Enforcer reduced the TSS of the fly ash slurry by an average of 77.9% based on the three replicates.

- Curlex Sediment Logs and Curlex Enforcer reduced the turbidity of the fly ash slurry by an average of 76.2% based on the three replicates (Figure 18).

Figure 15. Fly ash on Curlex Sediment Log and between Curlex Enforcer (shown after Curlex Sediment Log was removed from channel bottom following a test).

Figure 16. Fly ash collection within Curlex Sediment Log.

Figure 17. Fly ash within Curlex Enforcer following a filtration test.

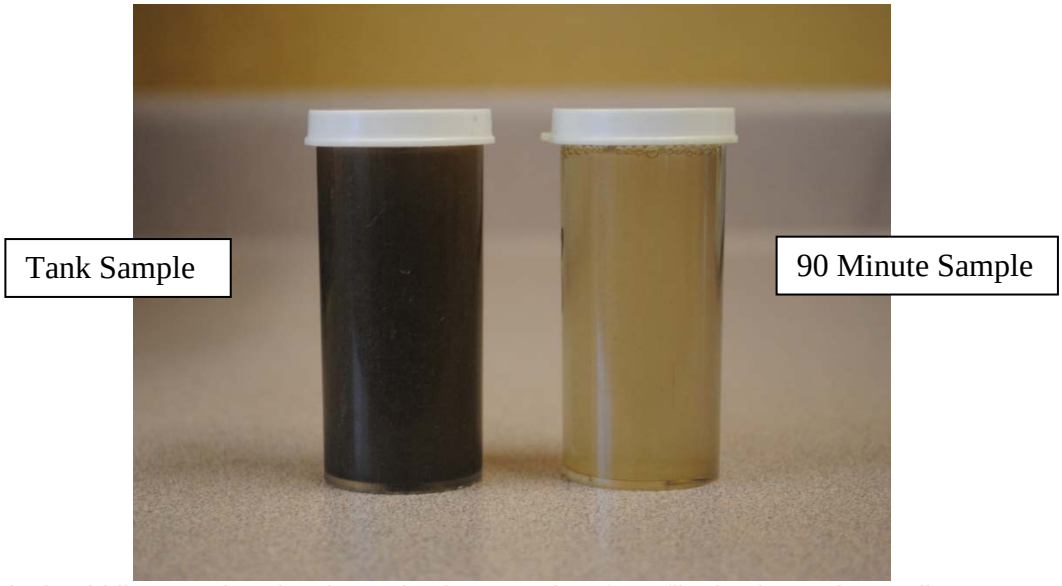

Figure 18. Typical turbidity samples showing reduction over time from filtering by Curlex Sediment Logs and Curlex Enforcer.